# *MAGMA INTRUSION RATE IN THE THREE SISTERS AREA OF THE CENTRAL OREGON CASCADES INFERRED BY DIFFERENT METHODS*

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Ongoing crustal uplift in the Three Sisters area was recently detected by InSAR imaging. The uplift is centered several km west of the Cascades crest at a location lacking young volcanic vents. Elastic models of the uplift invoke magma intrusion at a rate of ~0.006 $km^3$/yr beginning in 1998 (Wicks et al., 2001). Slightly anomalous water temperatures and $Cl^-$ concentrations were recognized in springs in this area a decade prior to the onset of uplift. The shallow groundwater system is apparently influenced by diffuse leakage of hydrothermal fluid from a reservoir beneath the western flanks of South Sister. The maximum thermal and $Cl^-$ anomalies are only about 5°C and 20 mg/L, respectively, in the most concentrated springs, but the combined discharge from all the springs is large and thought to account for most of the 3.5 $m^3$/s late-summer stream-flow in Separation Creek. Flow and $Cl^-$ concentration measurements in Separation Creek can thus be combined with the temperature-$Cl^-$ relation in the springs to calculate a total advective heat discharge of 16 MW. This corresponds to the heat released by the cooling and crystallization of ~0.0003 $km^3$/yr of magma.

A new sample set collected from Separation Creek in the summer of 2001 found no change in total heat discharge relative to 1990 measurements. However, isotopic work begun in 2001 revealed magmatic carbon and helium in the spring waters. The concentration of magmatic carbon is low, a few mmol/kg at most, and uncorrelated with $Cl^-$; but an average value for all the springs in the area can be estimated. Combining this average with the late-summer water flow results in a discharge of 7700 tonnes of magmatic $CO_2$ per year. This corresponds to the complete degassing of ~0.0005 $km^3$/yr of magma, assuming 0.65 wt.-% $CO_2$ in the magma. Both the total heat and magmatic carbon discharges are probably accurate to within a factor of two and correspond to intrusion rates that agree within a factor of two. The heat discharge (and by inference, the carbon discharge) may reflect some longer-term intrusion rate. If so, the present intrusion rate inferred from InSAR imaging is at least an order of magnitude larger than the longer-term intrusion rate in this area.